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THE KILLER THAT FEW HAVE SEEN

Bjorn Bergland from the Zoological Laboratory, Bergen, is hunting for a killer. He started his detective work after some smolt developed unexplained sores at the Trovag Salmon Farm in Vikebygd in fall 1987. The suspect, lamprey, looks like an eel. It is well known that this about 1 m long animal likes to cling to haddock and salmon.

Berland emphasizes that this is just a guess, because very few have encountered live lampreys, and that it will remain a guess until someone catches this predator in a fish pen.

WOUNDS IN SEA-FARMED SMOLT

Bjorn Berland,
Zoological Laboratory,
Bergen University

During a course on fish diseases, organized for the National Association of Farmed Fish Producers at the Zoological Laboratory, Bergen University in January 1988, Reidar Andersen, one of the participants from Trovag Salmon A/S, Vikebygd, reported as follows : He had transplanted smolt in the fall in a sea facility situated in Skaanevik Fjord, Sunnhordaland. The depth was 40 m under the facility and increased significantly just outside it. The fish were transplanted in fall 1987, and, according to him, they weighed about 100 g in January-February 1988. This facility suffered some mortality : the fish were otherwise fine but each morning some of them were found lying dead at the bottom of the pens, and by the end of January

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1988, about 10 % had died. He reported that the fish were in a fine condition without injuries while in the pens during daytime, so that the injuries must have taken place suddenly during the night, with lethal results. All dead fish had the same round/oval wounds on their bodies, which were not just surficial lesions but extended in some degree into the underlying muscles. He asked whether we, as zoologists, could supply him an explanation for these sudden injuries. My colleague, research assistant Helge Leivestad and I immediately thought of hagfish and suggested that Andersen turn on lights at night. Andersen reported that after lights were turned on at night, the situation became somewhat better, that is, fewer smolt died each night.

Andersen saw recently a draft for this article with some comments. He reported by letter that another 15-20 % of the smolt died during the course of the winter and spring 1988, so that the total loss among the smolts placed in this facility amounted to 25-30 %. Furthermore, he reported that when the lights were turned on at night, the wound-related problems were immediately significantly reduced but that they increased again quite a lot before declining and coming to an end in April/May. Andersen reports further, that besides the dead fish on the bottom, a number of wounded fish were seen to swim around a few days before they died. As long as the fish were alive, they kept on feeding.

Samples

At the end of January 1988, Andersen sent us a sample of 7 dead smolt in a thermos with ice. We shook them out of the thermos to study them, took color photos and had them fixed in formaldehyde solution.

The fish had visible wounds (Fig. 1). Each fish had just one big wound. On 4 fishes, the wounds were on the sides, on 2 fishes dorsally at the root of the tail, and on 1 fish ventrally at the root of the tail. The wounds were skinless and extended to the underlying tissue in some degree. As can be seen in Fig. 1, some wounds had rough edges. One fish had a big oval wound centrally on one side (15 x 20 mm; Figs. 1 and 2), with a depth of about 3 mm, another fish had a wound of 15 x 25 mm. The fish that had been fixed in formaldehyde solution were measured and weighed after several months : Length 14.5 - 16.5 cm, weight between 40 and 60 g, with an average of 49 cm. This was only half of the weight indicated earlier.

What could the wounds be caused by ? We can exclude bacterial and protozoan diseases, as they do not occur this acutely. Hagfish (Myxine) can be excluded as well, as they prey on carcasses and bore into and literally empty the bodies of dying/dead fishes caught in traps. Usually they bore into a fish just behind the pectoral fin where the belly wall is thin, leaving behind only an empty skin sac and the skeleton. Eel pots baited with dead fish can yield a good catch of hagfish. It is not probable that hagfish could attack a swimming fish.

It was obvious that the attacks had to be blamed on larger organisms, i.e., animals. The mesh size of the fish pens was about 12 x 12 mm. There are two alternatives. First, a relatively large organism staying outside the pen may stick its mouth or head into the pen. The second alternative comprises animals that stay in the pen with the salmon, which means that they can enter and exit through the meshes.

Candidates

Among the bigger animals, we can exclude seals, otters, and minks, because their teeth will leave completely different marks. The fish pens are as a rule safe against attacks from the air. As birds have to see their prey, it is little likely that they could hunt in the dark. Gulls and herons have to catch their prey from the surface. A bird would have to catch the fish with its bill, which would leave again quite different marks. Among the fish-eating divers, there are the cormorants and smews, which might occasionally manage to stick their bills through the meshes, and if they were successful in snapping at a fish, the latter would show cuts quite different from the wounds in question. Can fish farmers with facilities exposed to birds confirm/deny this ? A piece of news in New Scientist (24.03.1988, p.26) reports that seals and herons take annually salmon worth GBP 4 mill. from sea-farms in Scotland. Are these animals doing similar damage in Norwegian facilities ?

What about fish ? Sharks, in the first place the spiny dogfish, can enter fish pens by cutting some meshes, but then of course some smaller salmon would escape. One of my colleagues reported that dogfish have been observed in fish pens but that they have stayed near the bottom, eating dead fish. The sharks can move their jaws in such a manner that they can take bites from their prey, but they must be considered unlikely candidates in this context.

Wrasses, such as the ballan, have strong front teeth for prying small animals loose from a solid substrate. Some wrasses are known to be able to remove parasites from the mouth and skin of bony fish. Thus, the possibility of controlling salmon louse by means of wrasses is being studied. It is difficult to imagine that they could push their jaws into a fish pen so much that they could take bites from fishes swimming by.

Cephalopods, such as the octopus, have slim arms with suckers, and they can theoretically stick them through the meshes and grab fish, and they also have a "parrot beak" to bite holes in the skin, and a rasping tongue. The wounds do not indicate cephalopods, and I consider them unlikely but not excludable. The octopus is a greedy animal. Have some sea facilities been exposed to attention by octopuses in "the octopus years" ?

Small or slim

We can now draw the conclusion that the predators do not stay outside the fish pens. As they have not been found in the pens with wounded smolt, they must be so small, or so slim, that they can enter and exit through the meshes without particular difficulty.

Leeches may attach themselves to fish to suck blood, but their suckers are fairly small, and they are not known to make this kind of wounds. Have leeches been ever observed on salmonid fishes in saltwater ? According to Margolis (1982), three species of freshwater leeches are known from Pacific salmon in freshwaters in Siberia and North America.

Salmon louse is a candidate as well, as it can cause wounds in the skin, mainly on the head and neck. Fish farmers know the injuries caused by the lice, and they are excluded. Some kelp lice and mites (botnius) are typically necrophagous, gnawing on dying/dead fish caught in fishing gear placed in the bottom, and these can be excluded as well.

In my opinion, only three candidates remain : hagfish, common eel, and lamprey. Hagfish has been excluded already. The common eel could enter and exit the pens, but it has sharp teeth not suited for cutting out round neat pieces of tissue.

Thus, the only candidate left is lamprey. It is not a fish (and neither are the hagfish, but they are still included in books on fish) but belongs to the cyclostomes. Its Norwegian name "nine-eyes" comes from its having 9 openings or "eyes" on each side : one for nose, one pair of eyes, and seven pairs of gill slits. These very primitive vertebrates are shaped like eels, they lack paired fins but have dorsal fins. They lack mandibles as well; the head, mouth, and the gill system are supported by an internal cartilage. They also lack real teeth; the mouth opening lies centrally in a round suction plate with horny teeth. They are good swimmers. With their powerful sucker, they can grab a hold not just on stones but whales and fishes for transport as well. With their horny teeth, they can easily penetrate the skin and get to the underlying tissue. One manual reports that they live on fish and whale blood, another one that they attach themselves to salmon in streams, preferably at night, while during the day they are attached to stones.

1-mm eggs

The biology of the lamprey is similar to that of salmon. They spawn in freshwater, migrate to the sea, and then return to freshwater to spawn. Small forms develop in freshwater which do not migrate, and bigger ones which do, like the salmon. The lamprey eggs are about 1 mm in diameter, but big females may produce a couple of hundred thousand eggs. The larva is quite special. It is called ammocoetes (in Norwegian "sandell", in Swedish "linaal"). The larva is slim like an eel and lies in the river bottom between sand and gravel grains. It lives in this manner for several years and feeds by filtering micro-organisms - bacteria, algae, and unicellular organisms - with its gill system. After some years in the gravel, it metamorphoses into the typical adult form and swims downstream. Those migrating out into the sea may travel quite far, and they can live in the sea for several years and grow very big; the species called sea lamprey may grow to a length of 1 meter. When they approach sexual maturity, they migrate back to freshwater to spawn. After the intestines of the adult lampreys undergo involution, so that they can no longer feed, they die after spawning, just like the salmon .

Lampreys did not occur earlier in the Great Lakes, but after the locks at the Niagara Falls were opened, they were able to migrate up into the Lakes, which took almost 100 years, with catastrophic results for fish since the 1930s.

Some manuals report that adult lampreys parasitize fish, while other manuals claim that they are predators. A parasite is not supposed to kill its host, while a predator does kill its prey.

According to Hera'd (1961), sea lampreys feed exclusively on blood, while some freshwater species also feed on muscles.

Four species

Four lamprey species are found in Norway (see Pethon 1985). One of them is an eastern Arctic species known from Pasvik only. Another one, the brook lamprey, spends its life in freshwater and is found in Sorlandet and Ostlandet (south coast of Norway and East Norway). The remaining two, the sea lamprey (Petromyzon marinus) and the lampern (Lampetra fluviatilis) migrate to the sea and are therefore of present interest.

The lampern ("Lampetra" derives from "lambo" which means to suck, to lick, or to lip) attains a length of 30-40 cm, and its suctorial mouth makes up about 5.6 % of its body length (Vladykov 1984). Thus, a 30-cm long lampern has a sucker with a diameter of 16-17 mm. According to Pethon (1985), "the lampern is a predator in the sea, attaching itself to other fishes (cod, sea trout, etc.) to suck their blood and body fluid, and its spit also prevents the blood from coagulating." The same source reports that the lampern "occurs along the European coast of the Atlantic northwards to Vestlandet (West Norway) and to the Baltic Sea. In Norway, the lampern is found up to the Bergen region and the rivers within this area." However, according to Eggan & Johnsen (1983), its distribution covers large parts of East Norway, while, with the exception of an uncertain report from Rogaland, it seems not to occur in the rivers of the West Norwegian counties.

The sea lamprey attains a length close to 1 meter. The adult is marbled brown and black. Its scientific name "Petromyzon" means "stone-sucker" ("petro" = stone; "myzon" = to suck). It mates in running freshwater in early summer, and the ammocoetes larvae lie in the bottom gravel for 4-5 years before metamorphosing and then migrating out to the sea in a couple of months, when they are 14-20 cm long. The suctorial mouth is quite large; according to Vladykov, its diameter constitutes 7.5 - 10 % of the body length.

Vladykov also reports that the sea lamprey is parasitic to a major degree in that it finds its food in many fish species and marine mammals as well (whales). Wheeler (1978) reports that out in the open sea, it has been found attached to sharks (basking shark) as well.

Blood-sucker

According to Pethon (1985), "we know little about the marine life of the sea lamprey except that it is a predatory animal. It likes to grab a hold on haddock and salmon but has been found also on sharks, whales, and boats. It breaks the skin of the fish with the teeth on its suctorial plate, and using its tongue as a punch, proceeds to suck blood and body fluids from its prey. Its pharynxal glands secrete an anticoagulant "spit" which facilitates the sucking."

Pethon reports further that "the fish travels partly independently and partly by attaching itself to other fishes such as salmon, to be transported by the latter". According to other sources (Muus & Dahlstrom 1965), the sea lamprey lives "as a blood-sucker and carrion-feeder, frequently maintaining suction on cod, herring, mackerel, and shark". Also, that it "hangs on salmon in rivers". Muus & Dahlstrom (1965, p. 31) show in a drawing accompanying their chapter on cyclostomes a salmon with a lamprey fastened on its body. This may indicate that this is so common in waters having both lampreys and salmon that no special mention is made about it.

In Norway, the sea lamprey is known from freshwaters in a number of coastal communities in the south and east and in the counties of Trondelag. For West Norway is reported one community in Rogaland and for Hordaland there is an uncertain report from Granvin (Eggan & Johnsen 1983). According to Pethon (1985), the sea lamprey's distribution area in the eastern Atlantic extends from West Africa and the Mediterranean to Iceland and Finnmark, which is shown in his distribution map, but for Norway, Pethon reports that the sea lamprey is found "distributed along the coast and the rivers within". Its distribution in the rivers can be assumed to be well known, but it is poorly known where and how long it stays in the sea. I once found, at the end of the 1950s, a big lamprey, which must have been a sea lamprey, in the stomach of a Greenland shark at the East Greenland coast.

A survey of the parasites of the Pacific salmon (Margolis 1982) mentions three different lampreys (Lampetra species) which have been found to attack the salmon in the Pacific.

Caught in Sunndal

During a course in Bergen in January 1987, I learned that lampreys had been seen in a hatchery/fish-farm (freshwater) in Mauranger, Hardanger (source: Sveinung Sandvik, Mauranger Laks A/S, 5976 Mauranger). Recently I was told (Ivar Holmefjord, M.Sc., Bergen) that a live lamprey was caught in the saltwater filtering basin for halibut tanks at the Sunndalsora Research Plant in the beginning of April 1988. It had entered the system through the saltwater intake at a depth of 35 m and made its way through the pump. This proves clearly that the lamprey occurs at the coast but that it is seldom or never seen in the sea.

The size and form of the typical wounds on the farmed fish fit fairly well the size and form of the mouth of larger lamperns and medium sea lampreys. We know that they live in the sea, but we know little about how far they migrate, where they stay and what they eat. Should we believe that the farmed fish "smell" so good that they attract uninvited guests to the fish pens ? And why not rasp away a bigger piece of fish than just one little bite ? Are the lampreys more interested in blood than muscles ? Where do they stay during the day ? Do they attach themselves to rocks and stones or hide in cavities ?

"Textbook animal"

The lampreys are "textbook animals" - most of us read about them but few have seen them alive. Until a lamprey is observed or caught in a fish pen, we can only guess. Would it be possible to place a very fine-meshed net at the bottom under the pens and then hoist it during the night ? We hope that a reader will happen to see lampreys in fish-producing or sea-farming facilities and succeeds in catching them and then forwards them (frozen, fixed in formaldehyde or salted) for documentation and species identification.

I have heard reports of something called "winter wounds", but obviously no-one knows anything about them. Can the injuries observed in smolt be

called winter wounds ? According to my understanding, winter wounds develop gradually during the cold winter months. However, the 1987-88 winter was exceptionally mild in West Norway, with surficial temperatures much higher than normal. As winter wounds are attributed to low temperatures, they should not have occurred this winter. It is probable that many owners of consumption fish farms will begin to view dead fish differently from now on.

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Summary

A marine fish farm in Skånevikfjorden, Hordaland, experienced daily sudden and unexplained deaths among smolts launched in autumn of 1987. At the end of January 1988 a sample of 7 dead smolts, 14,4 - 16,5 cm in length, and with conspicuous skin sores, were received at Zoologisk laboratorium, University of Bergen, with a request for explaining the cause of death. By eliminating in turn mammals, birds and several invertebrate candidates as possible killers, the only likely candidate is believed to be the lamprey. In South Norway two species of lampreys - Petromyzon marinus and Lampetra fluviatilis - migrate to sea. As no lampreys apparently have neither been reported, nor caught, in marine fish farm in Norway, the evidence is circumstantial. Fish farmers are requested to look for lampreys and if catching any, to preserve them for documentationm and specific identification.

Bergen 8. august 1988

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